EUV emission from Laser Assisted Vacuum Arc

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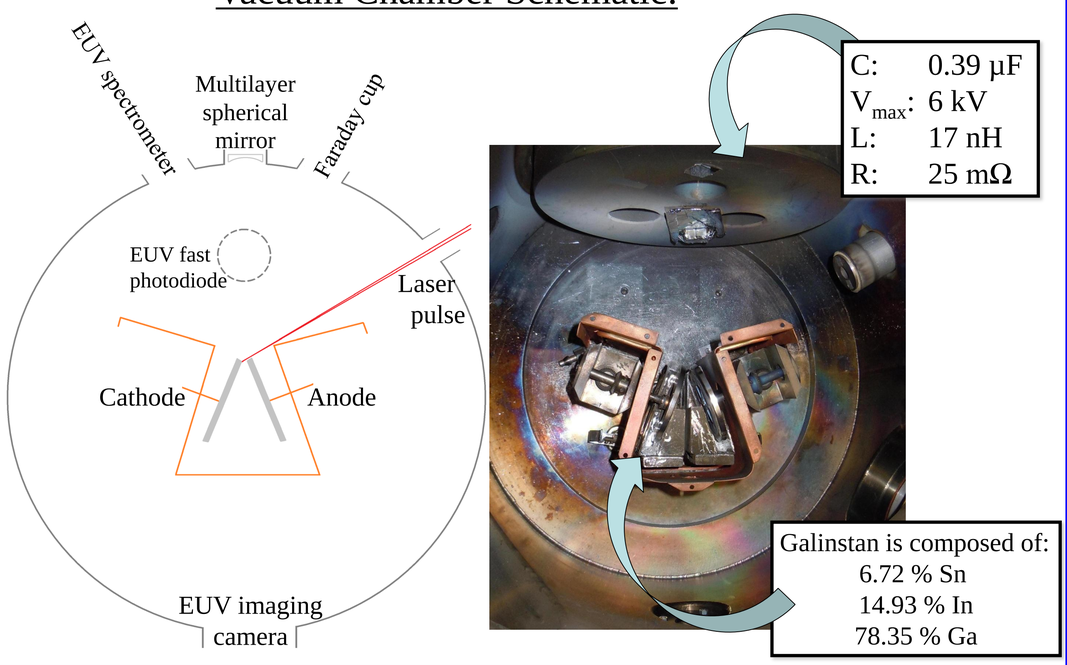
Current prototype EUV sources for lithography utilise tin as a source material. Galinstan (Ga-In-Sn) as a fuel material in this type of source is novel as it is liquid at room temperature. In this the EUV emission characteristics of galinstan and Sn are compared for the similar source parameters. In the LAVA-lamp source a high-current discharge is triggered by laser ablation of the liquid metal film on one of the rotating electrodes.

The results have so far shown that in-band EUV emission at 13.5 nm from Sn is more reproducible and between 1.5x and 10x higher than from galinstan. The low percentage of Sn (6.72%) and strong out-of-band EUV emission from Ga and In ions could be the cause of the lower in-band efficiency. The source parameters were also optimised only for Sn and not for galinstan which should yield improvement as indicated by results at lower discharge energies.

Experimental Setup

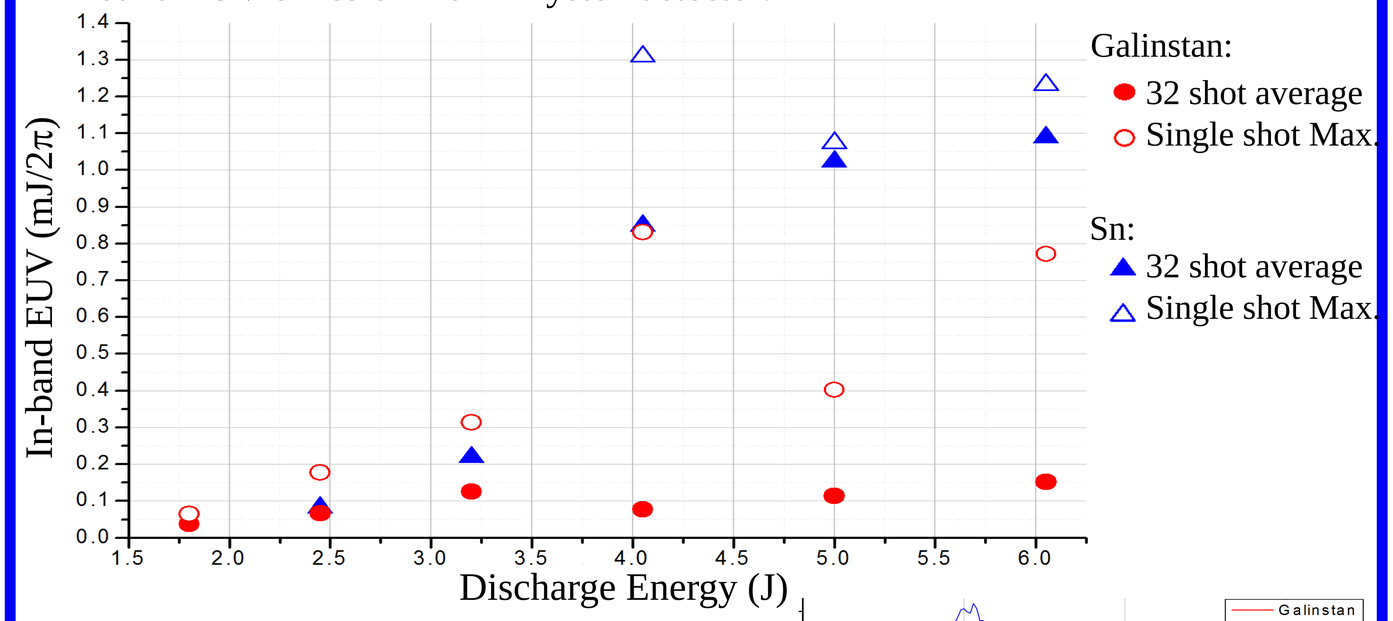
- **Jenoptik absolutely calibrated time integrated EUV spectrometer,**
- **2 μm spatially-resolved time-integrated in-band EUV imaging of the pinch,**
- **Phystex in-band EUV filtered detecting photodiode,**
- **Rogowski coil characterisation of discharge current**
- time- and spatially-resolved fast gated visible emission spectroscopy,
- time of flight diagnostic of ions with a Faraday cup

Vacuum Chamber Schematic:

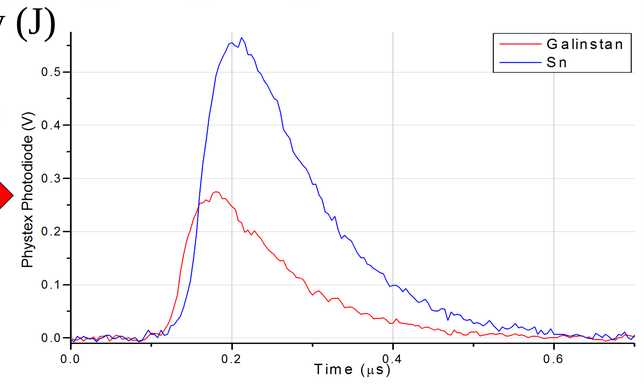


Phystex EUV Diode

➢ Inband EUV emission from Phystex detector:



4.05 J (4.5 kV) discharge with 12 mJ laser energy:

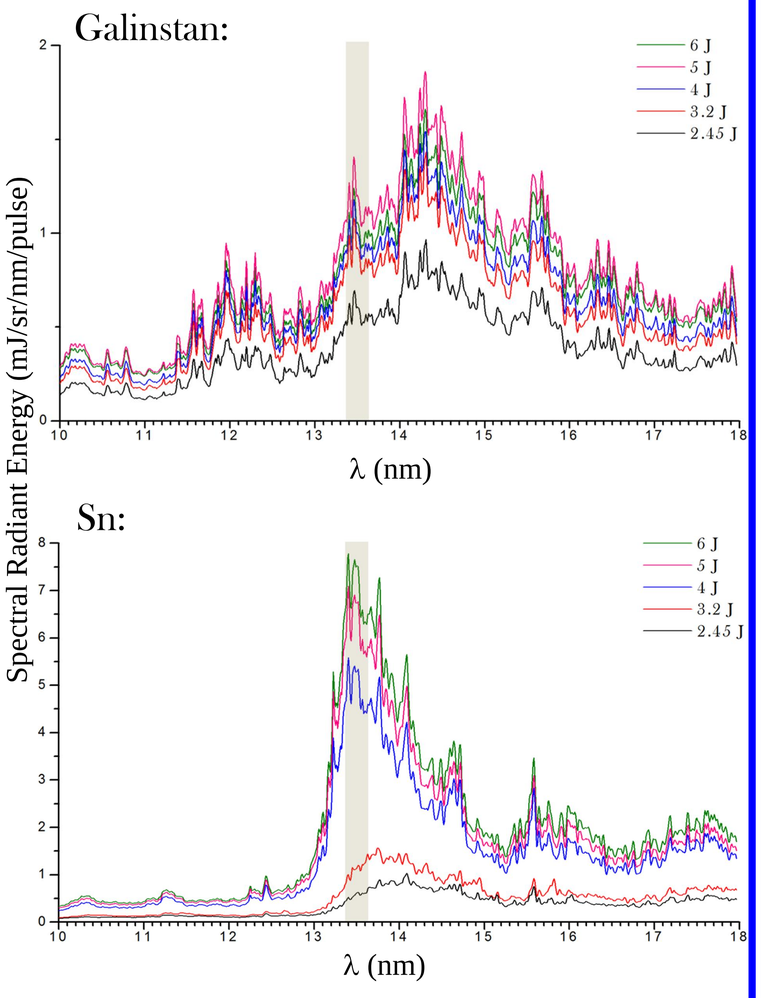


- Both plots are of the maximum EUV emission recorded
- Galinstan contains lighter elements than Sn

:. the discharge begins faster

Further Analysis

Jenoptik EUV spectra for various discharge energies:



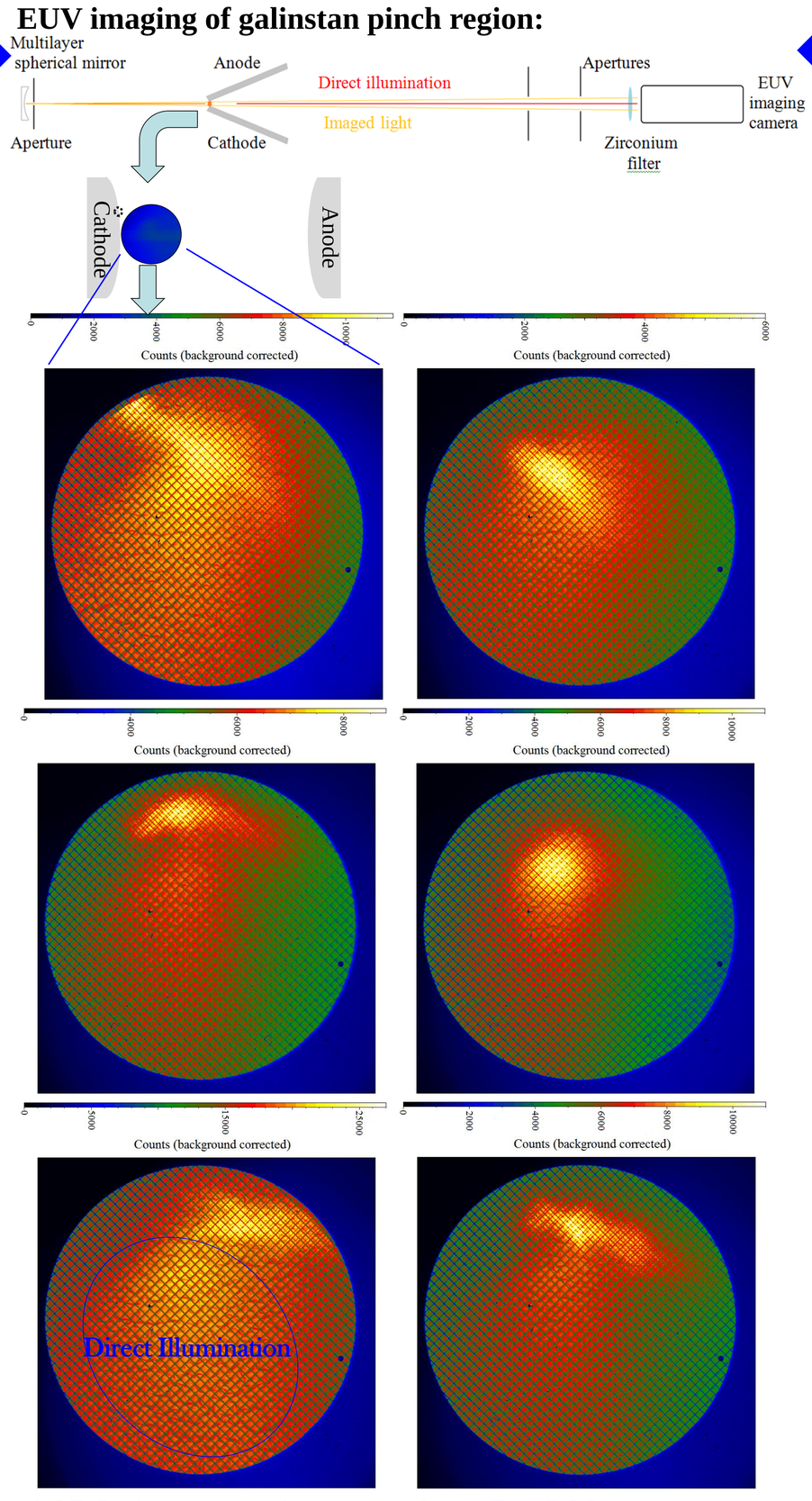
- In-band measure of EUV from spectra agrees well with data from Phystex results
- Both plateaux around 4 J discharge

Maximum in-band EUV emission* observed:

	(4 kV) **3.2 J**	**(**4.5 kV) **4.05 J**	(5.5 kV) **6.05 J**
Galinstan	**3.1 mJ/2π**	**8.3 mJ/2π**	**7.7 mJ/2π**
Sn	**2.2 mJ/2π**	**13.1 mJ/2π**	**12.3 mJ/2π**

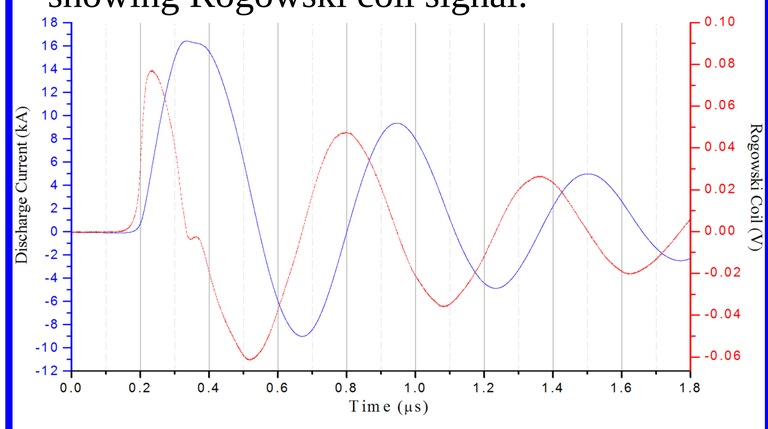
*from Phystex assuming emission over 2π

EUV imaging of galinstan pinch region:



4.05 J discharge triggered with a 5 mJ 30 ns laser pulse.

Discharge current profile showing Rogowski coil signal:



Conclusions:

We have compared the performance of galinstan and Sn in a laser triggered discharge source

- Galinstan is useful source material as avoids the complication of keeping Sn molten.
- So far we have observed EUV emission from Sn to be more efficient by a factor of between 1.5x and 10x.

  → lower EUV emission could be caused by low percentage of Sn or strong out-of-band EUV emission from Ga and In ions.
- Matching the pinching time to the maximum current is essential for high EUV output and is sensitive to trigger laser energy.
- EUV imaging – pinch is ~ 100 μm in diameter and ~ 0.5 mm – 1 mm in length.

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